

# Vacuum Fluctuation (1): the Same Basis of the Relativity and the Quantum Mechanics

Xing-Hao Ye\*

*Department of Physics, Zhejiang University, Hangzhou 310027, China*

(Dated: February 1, 2008)

The aim of this paper is to reveal the deep relationship between matter and vacuum, and to seek for the same physical basis of the relativity and the quantum mechanics. In doing this, three postulates of vacuum fluctuation are proposed first, the basic premises of the relativity and the quantum mechanics including the velocity limit, the energy-frequency relation and the de Broglie wavelength expression of any matter particles are deduced then. As applications, the idea is used to analyze the Compton effect and the electron-positron annihilation. It is found that the calculation becomes simple, and the physical meaning gets clear. The simplicity comes from the power of the three postulates. To illustrate this, the basic conclusions of the special theory of relativity such as the relations of mass-velocity, mass-energy, energy-momentum, time dilation and length contraction are further deduced. In addition, the significance of the investigation of vacuum fluctuation in the unification of the physical theories is pointed out.

PACS numbers: 03.65.-w, 42.50.Lc, 03.30.+p

## I. INTRODUCTION

The theory of relativity and the quantum mechanics are the two bases of the twentieth century physics which has achieved great success and made strong impact on many other fields. Since the two theories have been tested widely in practice, there is no doubt about their correctness. Yet, they are not the ultimate theories. As we know that, the two theories answered only the question “how” rather than “why”. For example, the theory of relativity pointed out only that the velocity of light in vacuum is a maximum and a constant, without giving its reason; and the quantum mechanics described only the probability of microcosmic particles, but not its mechanism. Besides, there is only a calculational combination of the two theories, but not a physical unification. Therefore, difficulties arise when fundamental problems are considered. Today, problems such as the interference of a single photon [1], the quantum entanglement and nonlocal correlation [2, 3], the origin of mass [4, 5], the creation of particles [6], the confinement of quarks [7], the origin and evolution of the universe [8], the nature of dark matter and dark energy [9, 10], the Hawking radiation of black holes [11, 12], the nature of space and time [8, 13], the relation between the four fundamental interactions and the unification of the theory of gravity and the quantum mechanics [14, 15] etc., are all calling for the investigation of the true foundation of the existing theories.

On the other hand, people have long thought that the most fundamental problems of physics may all be related to the quantum vacuum. It is believed that vacuum will be an entrance to the complete understanding of the physical world and to the ultimate unification of the physical theories.

One of the fundamental problems is: “What are the fundamental elements of the physical world?” Today, there are too many members of fundamental particles we have discovered, so they are not truly fundamental. Some scientists suggest that strings or quantum loops may be the fundamental ones. But

still, there are too many types of strings or loops in their theories, and we may ask further that: “What are those strings or loops composed of?” In principle, the fundamental elements of the world must be simple in characteristic and minimal in type, just as the binary numbers “0” and “1” can form every type of information in computer science. The ancient Chinese philosophy and the modern quantum theory may give us revelation. In Chinese Taoism, Tao produces Yuanqi (original energy) and Yuanqi is divided into Yin (the dark or negative side) and Yang (the light or positive side). Yin and Yang are opposite and mutually complementary, and the balance or harmony of Yin and Yang forms the essence of everything [16]. In modern quantum theory of field, particles are regarded as states excited from the vacuum, that is to say, particles and antiparticles can be excited or created from the quantum vacuum under certain condition. The idea was first proposed by Dirac in 1928 and 1930. In his papers, vacuum was regarded as a “negative energy sea”, from which electron could be excited and antielectron could be formed [17]. The predicted antielectron was discovered soon by Anderson in 1932 [18]. After then, many antiparticles were found in succession. The fact leads to the thought that all the matters may be originated from vacuum and vacuum may be composed fundamentally of two opposite elements. It means that vacuum is not just an empty void, but a special physical existence — this has been verified to be true. In 1948, Casimir proposed that the zero point fluctuation of vacuum can be measured through an attractive effect [19], which was examined experimentally by Lamoreaux in 1997 [20]. Also, there are other phenomena that show the non-empty property of the vacuum, among which are the electron anomalous magnetic moment and Lamb shift [21], the light polarization rotation in vacuum in the presence of a transverse magnetic field [22], etc.

A second fundamental problem is: “What is gravitation? Can gravitation be interpreted on a more fundamental basis and thus be unified with other fundamental forces?” Early in 1920, Einstein [23] stated that “according to the general theory of relativity space is endowed with physical qualities; in this sense, therefore, there exists an ether.” In 1920, Eddington [24] proposed that the space could be regarded as a special op-

---

\*Electronic address: yxhow@163.com

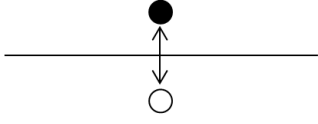


FIG. 1: Positive-negative vacufluctons.

tical medium whose refractive index varies with the distance to the gravitational matter and that the deflection of light in a gravitational field could be interpreted as an effect of refraction in a flat spacetime. This view of gravitational space was developed later by Wilson [25], Dicke [26], Felice [27], Nandi *et al.* [28, 29, 30]. Recently, this way in treating the gravitational force has been investigated further by Puthoff [31, 32], Vlokh [33], etc [34]. In their view, the ether or space stated above is just related to the quantum vacuum, and through the study of which, a true understanding of the gravitation would be acquired.

Besides the above, there are other fundamental problems such as “What is inertia?”, “What is mass”, etc., being considered to be related to the quantum vacuum [35, 36, 37, 38, 39].

So it is reasonable to say that vacuum is a key to the understanding of nature!

The purpose of this paper is to find out the deep relationship between matter and vacuum, and to quest for the same physical basis of the theory of relativity and the quantum mechanics. To reach this aim, three postulates of vacuum fluctuation will be proposed first, which are quite simple and natural.

## II. BASIC POSTULATES OF VACUUM FLUCTUATION

### A. Postulate 1: Matter is a buildup of vacuum fluctuational particles

There are three questions associated with this postulate:

(1) What is a vacuum fluctuational particle?

A vacuum fluctuational particle (it will be called a “vacuflucton” bellow for short) is a most fundamental particle excited from the quantum vacuum. Basically, there are two types of vacufluctons: if we call one “positive vacuflucton”, then the other “negative vacuflucton” — each is the counterpart of the other (Fig.1). Vacufluctons are not fixed. They randomly emerge from and vanish into the vacuum.

In Fig. 1, the horizontal line represents the vacuum, if “●” represents a positive vacuflucton, then “○” a negative vacuflucton. When such a pair of positive-negative vacufluctons forms, there is an orientational motion of the matter in space by a mechanism of the vacufluctons vanishing here and emerging there; whereas a single type of vacufluctons could only have a random change of places, with no orientational motion formed.

It is necessary to point out that the “vacuum fluctuation” discussed here is different to the commonly said “zero-point fluctuation of the vacuum”. The properties that there are two opposite types of vacufluctons (“positive” and “negative”) and that the vacufluctons can randomly “emerge from and van-

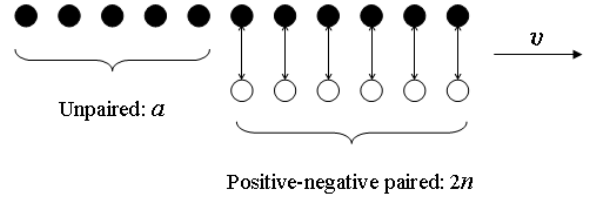


FIG. 2: A group of vacufluctons form a “fundamental particle”.

ish into the vacuum” indicate that the “vacuum fluctuation” discussed here is somewhat like the “vacuum polarization”, “vacuum excitation”, or “vacuum vibration”. But still, they are different concepts — when we say “vacuum fluctuational particles” or “vacufluctons”, we are investigating the more microscopic composition of matter and stressing its “growth and decline” or “eat and flow” relationship with vacuum.

(2) What is a “fundamental particle” composed of?

A commonly said “fundamental particle” such as a photon, an electron and others is composed of a large number of (that is, a group of) vacufluctons. Because of the random emerging and vanishing of the vacufluctons themselves, such a composition is quite complicated. Fig. 2 shows a simplified construction of a “fundamental particle”.

In Fig. 2, the  $a$  unpaired vacufluctons represent the rest matter. When they are added with  $2n$  positive-negative paired vacufluctons, the whole group of vacufluctons corresponding to the moving matter then have an orientational motion in space at velocity  $v$ . Hence, the total number of vacufluctons within a matter particle can be expressed generally as

$$Q = a + 2n. \quad (1)$$

Since the relativity of motion, the vacufluctons are also relative. That is, a certain number of vacufluctons observed in a reference frame may have a different number of vacufluctons in other frames. But in one frame, the total number of vacufluctons of an isolated system (containing particles 1, 2, ...,  $i$ , ...) is invariable, that is

$$d \sum Q_i = 0. \quad (2)$$

(3) What is the mass of a particle?

The mass of a particle reflects the quantity of matter. Therefore, the mass of a particle is directly proportional to the total number of vacufluctons it contains

$$m = k_1 Q, \quad (3)$$

where  $k_1$  is a constant.

### B. Postulate 2: The orientational motion of a group of vacufluctons forms the momentum of a particle

Because the orientational motion of a group of vacufluctons relies on the pairs of positive-negative vacufluctons, the momentum of a particle is then determined by the possibility of positive-negative pairing. It is postulated that

$$\vec{p} = m\vec{v} = k_2 \sqrt{(a+n)n}, \quad (4)$$

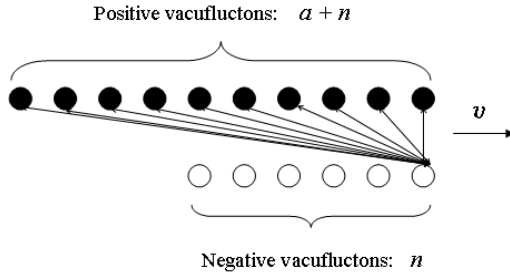


FIG. 3: The random pairing of positive-negative vacufluctons.

where  $k_2$  is also a constant. The total possibility of random pairing of positive-negative vacufluctons is figured out as  $(a + n)n$ . For instance, in Fig. 3, each negative vacuflucton can be the partner of  $a + n$  positive vacufluctons; therefore the total number of possible partnership is  $(a + n)n$ .

Because of the relativity of vacufluctons, the momentum of a particle is also relative. While in a certain frame of reference, the total momentum of an isolated system is conserved:

$$d \sum \vec{p}_i = 0. \quad (5)$$

### C. Postulate 3: The frequency of fluctuation is proportional to the number of vacufluctons

Each fluctuation, that is, each emerging and vanishing of a vacuflucton, is an interaction or a vibration between matter and vacuum. Therefore, the frequency of fluctuation of the group of vacufluctons is directly proportional to the total number of vacufluctons:

$$\nu = k_3 Q, \quad (6)$$

where  $k_3$  is another constant.

## III. DEDUCTIONS OF THE PREMISES OF THE RELATIVITY AND THE QUANTUM MECHANICS

### A. Velocity limit of a moving particle

Eq. (4) gives  $m\nu = k_2 \sqrt{(a + n)n}$ . Substituting Eqs. (1) and (3) yields

$$\nu = \frac{k_2}{k_1} \frac{\sqrt{(a + n)n}}{a + 2n}. \quad (7)$$

Through this relation, the condition of velocity limit can be obtained as  $a/n = 0$ , or  $a = 0$ , or  $n = \infty$ . Then the maximum velocity of a moving particle will be

$$\nu_{max} = \frac{k_2}{k_1} \frac{\sqrt{(0 + n)n}}{0 + 2n} = \frac{k_2}{2k_1}. \quad (8)$$

It shows that a particle of zero rest mass moves at a maximum velocity of  $k_2/2k_1$ , which is a uniform constant no matter

which reference frame is selected. And we know that a photon just satisfies this property. Therefore the velocity  $c$  of a photon in vacuum is the velocity limit for any moving particle:

$$\nu_{max} = \frac{k_2}{2k_1} = c. \quad (9)$$

This deduction corresponds to the basic premise of the special theory of relativity.

### B. Energy-frequency relation

Eqs. (4) and (9) give

$$\vec{p} = m\vec{v} = 2ck_1 \sqrt{(a + n)n}. \quad (10)$$

Through the definitions of force  $\vec{F} = d\vec{p}/dt$ , work  $dW = \vec{F} \cdot d\vec{s}$ , and kinetic energy  $dE_k = dW$ , we get

$$dE_k = (d\vec{p}) \cdot \vec{v} = v \cdot dp. \quad (11)$$

Substituting Eqs. (7), (9) and (10) into the above gives

$$dE_k = 2c \frac{\sqrt{(a + n)n}}{a + 2n} \cdot d[2ck_1 \sqrt{(a + n)n}]. \quad (12)$$

For a moving particle,  $a$  is a fixed number, while  $n$  is a variable. Thus we get  $dE_k = c^2 d(k_1 \cdot 2n)$ , or  $dE_k = c^2 d[k_1 \cdot (a + 2n)]$ . Associating this with Eqs. (1) and (3) gives

$$dE_k = c^2 dm. \quad (13)$$

Then, through the integration

$$E_k = \int_{m_0}^m c^2 dm, \quad (14)$$

we get  $E_k = mc^2 - m_0c^2$ , or  $E = E_0 + E_k = m_0c^2 + E_k = mc^2$ , where  $m_0$  is the rest mass,  $E_0 = m_0c^2$  is the rest energy. So there is the mass-energy relation

$$E = mc^2. \quad (15)$$

Associating Eqs. (3), (6) and (15) gives

$$E = \left(\frac{k_1}{k_3} c^2\right) \nu. \quad (16)$$

According to the law of blackbody radiation, the constant here is just the Planck constant  $h$ :

$$\left(\frac{k_1}{k_3} c^2\right) = h. \quad (17)$$

Then we have the energy-frequency relation

$$E = h\nu. \quad (18)$$

### C. de Broglie wavelength expression

Through Eqs. (11), (13) and (15) we know that the velocity of a moving particle is  $v = dE/dp$ . In the view of wave motion, it is the group velocity of the vacufluctons of the particle. Considering

$$v = \frac{dE}{dp} = \frac{d(h\nu)}{dp} = \frac{d\omega}{d(\frac{2\pi p}{h})}, \quad (19)$$

and the general expression of group velocity

$$v = \frac{d\omega}{dk}, \quad (20)$$

we have

$$\frac{2\pi p}{h} = k = \frac{2\pi}{\lambda}. \quad (21)$$

Thus we get

$$\lambda = \frac{h}{p}. \quad (22)$$

It is just the de Broglie wavelength expression.

The above two deductions, that is, the relations of energy-frequency and momentum-wavelength, show the wave-particle duality of any matter particles, which is the basic premise of the quantum mechanics. And we find that the two properties, that is, the wave property ( $\nu$ ,  $\lambda$ ) and the particle property ( $E$ ,  $p$ ), are connected through the Planck constant:  $E/\nu = h$ ,  $p\lambda = h$ . As a matter of fact, the Planck constant characterizes the generality and unity of vacuum fluctuation. We can see this from the value of the Planck constant. Eqs. (9) and (17) give the relation  $h = k_2^2/4k_1k_3$ . So the Planck constant  $h$  is an integration of the three constants  $k_1$ ,  $k_2$  and  $k_3$  of the vacuum fluctuation.

## IV. APPLICATIONS

### A. Compton effect

First, consider the numbers of vacufluctons before and after the interaction between the photon and electron (Fig.4). According to Postulate 1, the total number of vacufluctons of the system is conserved:

$$2n + a = 2n' + (a + 2n''), \quad (23)$$

where  $2n$  and  $2n'$  are the numbers of vacufluctons of the photon before and after the interaction respectively,  $a$  and  $a + 2n''$  are those of the electron. Then we have

$$n = n' + n''. \quad (24)$$

Second, consider the momentum of the system before and after the interaction. According to Eq.(4), the momentum ratio between the photon before the interaction, the photon and

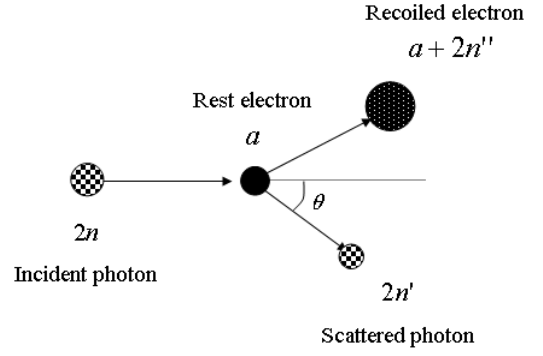


FIG. 4: Conservation of matter in Compton effect.

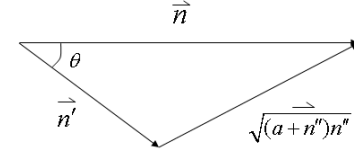


FIG. 5: Conservation of momentum in Compton effect.

the electron after the interaction is  $n : n' : \sqrt{(a+n'')n''}$ . Fig.5 shows this relation of the three momenta. Then, according to Postulate 2, the momentum of the system is conserved, we have

$$\vec{n} = \vec{n}' + \sqrt{(a+n'')n''}. \quad (25)$$

Associating Eqs.(24) and (25) gives

$$\frac{1}{n'} - \frac{1}{n} = \frac{2(1 - \cos \theta)}{a}, \quad (26)$$

where  $\theta$  is the scattering angle,  $a = m_{e0}/k_1$ ,  $m_{e0}$  is the rest mass of the electron.

Now, consider the change of the wavelength of the photon: Using Eq.(10), the de Broglie wavelength can be expressed as

$$\lambda = \frac{h}{2ck_1} \cdot \frac{1}{\sqrt{(a+n)n}}. \quad (27)$$

For a photon,  $a = 0$ , we have

$$\lambda = \frac{h}{2ck_1} \cdot \frac{1}{n}. \quad (28)$$

So the Compton shift  $\Delta\lambda$  is

$$\Delta\lambda = \lambda' - \lambda = \frac{h}{2ck_1} \left( \frac{1}{n'} - \frac{1}{n} \right), \quad (29)$$

where  $\lambda$  and  $\lambda'$  are the wavelengths of the incident photon and of the scattered photon respectively.

Associating Eqs.(26), (29) and the relation  $a = m_{e0}/k_1$  gives

$$\Delta\lambda = \frac{h}{m_{e0}c} (1 - \cos \theta). \quad (30)$$

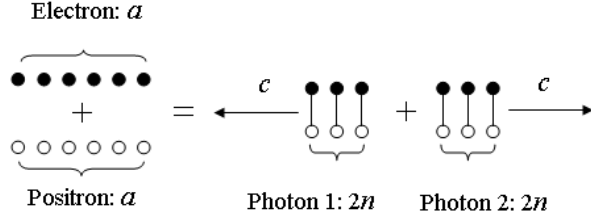


FIG. 6: The annihilation of an electron-positron pair.

### B. Creation and annihilation of electron-positron pairs

The idea of vacufluctons will provide us a simple description of the creation and annihilation of electron-positron pairs. To illustrate this, we will discuss the annihilation of an electron-positron pair below. For simplicity, here we assume that the electron and the positron are both at rest initially. The conservation of matter and momentum gives

$$\begin{aligned} a + a &= 2n_1 + 2n_2, \\ 0 &= \vec{n}_1 + \vec{n}_2. \end{aligned} \quad (31)$$

We get

$$\begin{aligned} \vec{n}_1 &= -\vec{n}_2, \\ 2n_1 &= 2n_2 = a. \end{aligned} \quad (32)$$

That is, the electron-positron pair will change symmetrically into a pair of photons moving towards two opposite directions. Fig.6 shows a simplified description of this annihilation.

## V. FURTHER DEDUCTIONS OF THE SPECIAL THEORY OF RELATIVITY

Compared with the usual method, the calculation of the Compton shift and the electron-positron annihilation here is simple, which needs no use of the relations  $E = mc^2$  and  $m = m_0 / \sqrt{1 - v^2/c^2}$ . In fact, these and some other relations given by the special theory of relativity have already been embodied in the postulates of vacuum fluctuation. To illustrate this, the paper below will give the further deductions of the basic conclusions of the special theory of relativity, based only on the three postulates and their deductions given in Section 3.

### A. Mass-velocity relation

Eqs. (7) and (9) give the velocity of a matter particle

$$v = 2c \frac{\sqrt{(a+n)n}}{a+2n}, \quad (33)$$

where  $a$  vacufluctons form the rest mass of a moving particle

$$m_0 = k_1 \cdot a, \quad (34)$$

and  $2n$  vacufluctons form the increment of mass

$$\Delta m = k_1 \cdot 2n. \quad (35)$$

The total mass is

$$m = k_1 \cdot (a + 2n) = k_1 \cdot Q. \quad (36)$$

Combining Eqs. (33), (34) and (36), we obtain the mass-velocity relation

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}. \quad (37)$$

### B. Mass-energy relation

Substituting Eqs. (6), (3) and (17) into Eq. (18) gives the mass-energy relation

$$E = mc^2. \quad (38)$$

In fact, this relation can be directly deduced from the idea of vacufluctons, as shown in Eqs. (10) to (15).

If  $n = 0$ , we have the rest energy

$$E_0 = m_0 c^2. \quad (39)$$

Through Eqs. (2), (3) and (38) we get

$$d \sum E_i = 0. \quad (40)$$

It is just the conservation law of energy. In fact, the energy of matter is a sum of fluctuation energy of all the vacufluctons. And in average, there is no difference between the fluctuation energy of each vacuflucton. Therefore, the energy of matter must be directly proportional to its total number of vacufluctons. Thus the conservation of vacufluctons of an isolated system certainly leads to the conservation of energy.

### C. Energy-momentum relation

Substituting Eqs. (36), (34) into Eqs. (38), (39) gives

$$E = k_1(a + 2n)c^2, \quad (41)$$

and

$$E_0 = k_1 a c^2. \quad (42)$$

Then we have

$$E^2 - E_0^2 = [2ck_1 \sqrt{(a+n)n}]^2 c^2. \quad (43)$$

Combining this with Eq. (10) gives the energy-momentum relation

$$E^2 = p^2 c^2 + E_0^2. \quad (44)$$

### D. Time dilation

Eqs. (18) and (22) give the phase velocity of a matter wave

$$V_\varphi = \lambda v = \frac{h}{p} \cdot \frac{E}{h} = \frac{E}{p} = \frac{mc^2}{mV_g}, \quad (45)$$

where  $V_g$  is the group velocity of the vacufluctons, i.e., the velocity  $v$  of the matter particle.

Then we have

$$V_\varphi V_g = c^2. \quad (46)$$

Generally we have  $V_g \leq c$ , so there is  $V_\varphi \geq c$ .

The difference between the phase velocity and group velocity indicates that there is a phase shift within the group of vacufluctons. Assuming that this internal shift has a frequency of  $\nu_{in}$ , we have

$$\nu_{in} = \frac{V_\varphi - V_g}{\lambda} = v \frac{V_\varphi - V_g}{\lambda v} = v \left(1 - \frac{V_g}{V_\varphi}\right). \quad (47)$$

Associating Eqs. (33), (46) and (47) gives

$$\begin{aligned} \nu_{in} &= v \cdot \left[ \left(\frac{a+2n}{2}\right)^2 - (a+n)n \right] / \left(\frac{a+2n}{2}\right)^2 \\ &= v \cdot \left(\frac{a}{2}\right)^2 / \left(\frac{a+2n}{2}\right)^2. \end{aligned} \quad (48)$$

The physical meaning of the above equation is clear. In the equation,  $\nu$  is the fluctuation frequency of the whole group of vacufluctons, and  $[(a+2n)/2]^2$  is the number of possible positive-negative pairing in the ideal case as that of a photon (that is, the number of positive vacufluctons is just equal to that of negative vacufluctons, and the number of possible pairing reaches a maximum), while the actual number of possible pairing is  $(a+n)n$ , and  $(a/2)^2$  is the difference between these two. Obviously, in order to get the whole group of vacufluctons moving ahead at the same velocity, it is needed to change the positive-negative partnership between each other. It will therefore cause a phase shift within the group. That is, there will be an internal frequency of  $\nu_{in}$ , which can be a natural clock of the matter.

Substituting Eqs. (1) and (6) into Eq. (48) yields

$$\nu_{in} = k_3 a \cdot \frac{a}{a+2n}. \quad (49)$$

The rest internal frequency of this vacuflucton group (i.e.,  $n=0$ ) is

$$\nu_{in0} = k_3 a. \quad (50)$$

Then we have

$$\nu_{in} = \nu_{in0} \cdot \frac{a}{a+2n} = \nu_{in0} \cdot \frac{m_0}{m} = \nu_{in0} \sqrt{1 - \frac{v^2}{c^2}}. \quad (51)$$

It indicates that a moving clock runs slower than an identical stationary clock. Considering the relation  $T = 1/\nu$ , where

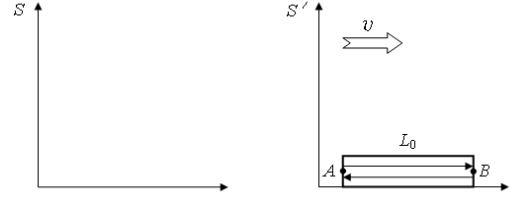


FIG. 7: Measuring the length of an object with a photon.

$T$  denotes the periodic time, then we have  $T = T_0 / \sqrt{1 - \frac{v^2}{c^2}}$ , which indicates that there is a time dilation effect

$$\Delta t = \Delta t_0 / \sqrt{1 - \frac{v^2}{c^2}}. \quad (52)$$

This effect can also be deduced through the Lorentz transformation. But here, through the investigation of the internal periodicity of the vacuflucton group, we get a more comprehensible view of the time dilation effect.

### E. Length contraction

According to Eq. (33), a photon ( $a=0$ ) moves in vacuum at a constant velocity of  $c$ , no matter which frame of reference is selected. So we can choose a photon as a uniform tool to measure the length of an object in different reference frames.

In Fig. 7, a rod  $AB$  is at rest in the frame  $S'$ , which is moving at velocity  $v$  relative to the frame  $S$ . A photon moves from  $A$  to  $B$  and returns to  $A$ . The time interval of this event measured in  $S'$  is

$$\Delta t_0 = \frac{2L_0}{c}, \quad (53)$$

where  $L_0$  is the length of the rod measured in  $S'$ .

Since points  $A$  and  $B$  are both moving at velocity  $v$  relative to  $S$ , so when observed in frame  $S$ , the photon moves a length of  $L + v \Delta t_{AB} = c \Delta t_{AB}$  from  $A$  to  $B$ , and a length of  $L - v \Delta t_{BA} = c \Delta t_{BA}$  back to  $A$ . Thus we get

$$\begin{aligned} \Delta t_{AB} &= \frac{L}{c - v}, \\ \Delta t_{BA} &= \frac{L}{c + v}, \end{aligned} \quad (54)$$

where  $L$  is the length of the rod measured in  $S$ .

Therefore, the time interval of the event measured in  $S$  is

$$\Delta t = \Delta t_{AB} + \Delta t_{BA} = \frac{2L}{(c^2 - v^2)/c}. \quad (55)$$

Through Eqs. (53) and (55) we get

$$\frac{\Delta t}{\Delta t_0} = \frac{L}{L_0} \cdot \frac{1}{1 - v^2/c^2}. \quad (56)$$

Substituting Eq. (52) into the above equation gives

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}. \quad (57)$$

It is just the length contraction of a moving object.

## VI. TESTING THE POSTULATES AND DETERMINING THE CONSTANTS

Eq.(28) gives the wavelength of a photon as:  $\lambda = h/2nck_1$ . Here we know that the product of the number of positive-negative paired vacufluctons of a photon and the wavelength of the photon is a constant, i.e.,  $2n\lambda = h/ck_1$ . Usually, the number  $2n$  is extremely large, so the wavelengths can almost form a continuous spectrum. However, under the condition of extremely low frequency, the discreteness of the electromagnetic spectrum may be observed ultimately. In such a case, every two wavelengths will be a ratio of two not-too-large integers, that is,  $\lambda_1/\lambda_2 = n_2/n_1$ . If such a relation is discovered in experiments, the postulates of vacufluctons can then be proved to be true.

Also, through the analysis of the data collected in such experiments, we will finally find the definite relation between  $\lambda$  and  $n$ . Then we could find out the value of constant  $k_1$ , and figure out the constants  $k_2$  and  $k_3$  through the relations  $k_2/2k_1 = c$  and  $c^2k_1/k_3 = h$ .

Considering that the frequency of the lowest electromagnetic waves people have already detected is on the order of the  $10^{-3}$  Hz [40], as an upper estimate, we have  $k_1 = h/2n\lambda c = hv/2nc^2 < hv/2c^2 = 3.68 \times 10^{-54}$  kg. It is already an extremely small mass — a mass 23 orders smaller than that of the electron.

## VII. CONCLUSIONS

The three postulates of vacuum fluctuation proposed in this paper provide an insight into the relationship between matter and vacuum. Vacuum is not just a place where particles stay and move; as a matter of fact, vacuum is the origin of all matter, motion and evolution. Therefore, the photon, electron and other matter particles could be unified at the level of vacuum fluctuational particles, or as we called, vacufluctons.

In Einstein's theory of relativity, it is just an assumption that the velocity of light in vacuum is a constant and is the limit of all the moving particles. While in this paper, it can be deduced

naturally from the postulates of vacuum fluctuation.

In the view of vacuum fluctuation, the Planck constant can be understood more profoundly. The value of the Planck constant is determined by the constants  $k_1$ ,  $k_2$  and  $k_3$ , that is,  $h = k_2^2/4k_1k_3$ . And the essential of the Planck constant is that it characterizes the generality and unity of vacuum fluctuation. Relatedly, the randomness and periodicity of the fluctuation of vacufluctons form the intrinsic characteristics of matter, leading to the so puzzling properties of uncertainty and wave-particle duality. The convenient deduction of the energy-frequency relation and the de Broglie wavelength expression from the postulates of vacufluctons shows the rationality of the ideas.

The simple calculation of the Compton shift and the electron-positron annihilation also shows the power of the three postulates. To illustrate this simplicity, the basic conclusions of the special theory of relativity such as the relations of mass-velocity, mass-energy, energy-momentum, time dilation and length contraction are further deduced. It is not that strange to see all the results being fully in agreement with that obtained through the Einstein's theory of relativity, because the basic premise of the special theory of relativity, that is, the constant velocity of light in vacuum, is just one of the deductions of the postulates of vacuum fluctuation.

In conclusion, it is suggested that the same physical basis of the theory of relativity and the quantum mechanics will be found through the investigation of vacuum fluctuation. Actually, a great many of results can be naturally deduced from the basic postulates of vacuum fluctuation. Furthermore, the investigation of vacuum fluctuation will open up a new way to deal with the inexplicable problems in physics today. In brief, it promises an approach to the unification of physical theories.

## Acknowledgments

I wish to acknowledge the supports from the Ministry of Science and Technology of China (grant no. 2006CB921403 & 2006 AA06A204) and the Zhejiang Provincial Qian-Jiang-Ren-Cai Project of China (grant no. 2006R10025).

- 
- [1] A. Zeilinger *et al*, *Happy centenary, photon*, Nature **433**, 230 (2005).
  - [2] M. Ikram, F. L. Li, and M. S. Zubairy, *Disentanglement in a two-qubit system subjected to dissipation environments*, Phys. Rev. A. **75**, 062336 (2007).
  - [3] J. de Boer, V. Jejjala, and D. Minic,  *$\alpha$ -states in de Sitter space*, Phys. Rev. D. **71**, 044013 (2005).
  - [4] G. Weiglein, *From the top....*, Nature **429**, 613 (2004).
  - [5] F. Wilczek, *In search of symmetry lost*, Nature **433**, 239 (2005).
  - [6] K. D. Lamb *et al*, *Unitary and nonunitary approaches in quantum field theory*, Phys. Rev. A. **75**, 013425 (2007).
  - [7] M. Baldo, *et al*, *Quark matter in neutron stars within the Nambu-Jona-Lasinio model and confinement*, Phys. Rev. C. **75**, 035804 (2007).
  - [8] M. Bojowald, *Cosmology: Original questions*, Nature **436**, 920 (2005).
  - [9] C. L. Bennett, *Cosmology from start to finish*, Nature **440**, 1126 (2006).
  - [10] C. L. Bennett, *Astrophysical Observations: Lensing and Eclipsing Einsteins Theories*, Science **307**, 879 (2005).
  - [11] G. W. Gibbons and E. P. S. Shellard, *Tales of Singularities*, Science **295**, 1476 (2002).
  - [12] S. Iso, H. Umetsu, and F. Wilczek, *Anomalies, Hawking radiations, and regularity in rotating black holes*, Phys. Rev. D. **74**, 044017 (2006).
  - [13] D. Campo and R. Parentani, *Space-time correlations within pairs produced during inflation: A wave-packet analysis*, Phys. Rev. D. **67**, 103522 (2003).
  - [14] G. A. Camelia, *Quantum theory's last challenge*, Nature **408**, 661 (2000).

- [15] L. J. Hall and Y. Nomura, *Complete theory of grand unification in five dimensions*, Phys. Rev. D. **66**, 075004 (2002).
- [16] *Chinese Religion: Taoism*, <http://www.china-guide.de/english>. Cited 16 Oct 2007 (2007); *Yin and yang*, <http://en.wikilib.com/wiki>. Cited 16 Jun 2006 (2006).
- [17] P. A. M. Dirac, *The Quantum Theory of the Electron*, Proc. Roy. Soc. **A117**, 610 (1928); *A Theory of Electrons and Protons*, **A126**, 360 (1930).
- [18] S. Weinberg, *The quantum Theory of Fields (Volume 1)* (Cambridge University Press, New York, 1995).
- [19] H. B. G. Casimir, *On The Attraction of Two Perfectly Conducting Plates*, Koninkl. Ned. Adak. Wetenschap. Proc. **51**, 793 (1948).
- [20] S. K. Lamoreaux, *Demonstration of the Casimir Force in the 0.6 to 6  $\mu\text{m}$  Range*, Phys. Rev. Lett. **78**, 5 (1997).
- [21] N. Ahmadi and M. Nouri-Zonoz, *Quantum gravitational optics: Effective Raychaudhuri equation*, Phys. Rev. D. **74**, 044034 (2006).
- [22] E. Zavattini *et al*, *Experimental Observation of Optical Rotation Generated in Vacuum by a Magnetic Field*, Phys. Rev. Lett. **96**, 110406 (2006).
- [23] A. Einstein, *Ether and the Theory of Relativity*, An address delivered on May 5th, 1920, in the University of Leydenon (1920).
- [24] A. S. Eddington, *Space, Time and Gravitation* (Cambridge University Press, Cambridge, 1920).
- [25] H. A. Wilson, *An Electromagnetic Theory of Gravitation*, Phys. Rev. **17**, 54 (1921).
- [26] R. H. Dicke, *Gravitation without a Principle of Equivalence*, Rev. Mod. Phys. **29**, 363 (1957).
- [27] F. Felice, *On the Gravitational Field Acting as an Optical Medium*, Gen. Rel. Grav. **2**, 347 (1971).
- [28] K. K. Nandi and A. Islam, *On the optical-mechanical analogy in general relativity*, Am. J. Phys. **63**, 251 (1995).
- [29] J. Evans, K. K. Nandi, and A. Islam, *The optical-mechanical analogy in general relativity: New methods for the paths of light and of the planets*, Am. J. Phys. **64**, 1404 (1996).
- [30] J. Evans, K. K. Nandi, and A. Islam, *The Optical-Mechanical Analogy in General Relativity: Exact Newtonian Forms for the Equations of Motion of Particles and Photons*, Gen. Rel. Grav. **28**, 413 (1996).
- [31] H. E. Puthoff, *Polarizable-Vacuum (PV) Approach to General Relativity*, Found. Phys. **32**, 927 (2002).
- [32] H. E. Puthoff, E. W. Davis, and C. Maccone, *Levi-Civita effect in the polarizable vacuum (PV) representation of general relativity*, Gen. Rel. Grav. **37**, 483 (2005).
- [33] R. Vlokh, *Change of Optical Properties of Space under Gravitational Field*, Ukr. J. Phys. Opt. **5**, 27 (2004); R. Vlokh and M. Kostyrko, *Reflection of Light Caused by Gravitational Field of Spherically Symmetric Mass*, Ukr. J. Phys. Opt. **6**, 120 (2005); R. Vlokh and M. Kostyrko, *Optical-Gravitation Nonlinearity: A Change of Gravitational Coefficient G Induced by Gravitational Field*, Ukr. J. Phys. Opt. **7**, 179 (2006).
- [34] X. H. Ye and Q. Lin, *A Simple Optical Analysis of Gravitational Lensing*, J. Mod. Optic. Accepted (2007).
- [35] B. Haisch, A. Rueda, and H. E. Puthoff, *Inertia as a Zero-Point Field Lorentz Force*, Phys. Rev. A. **49**, 678 (1994).
- [36] B. Haisch, A. Rueda, and H. E. Puthoff, *Advances in the Proposed Electromagnetic Zero-Point Field Theory of Inertia*, 34th AIAA/ASME/SAE/ASEE AIAA Joint Propulsion Conference, AIAA paper 98-3143 (1998).
- [37] B. Haisch, A. Rueda, and Y. Dobyns, *Inertial mass and the quantum vacuum fields*, Annalen der Physik **10**, 393 (2001).
- [38] Y. Dobyns, A. Rueda, and B. Haisch, *The Case for Inertia as a Vacuum Effect: A Reply to Woodward and Mahood*, Found. Phys. **30**(1), 59 (2000).
- [39] A. Rueda and B. Haisch, *Gravity and the quantum vacuum inertia hypothesis*, Annalen der Physik **14**(8), 479 (2005).
- [40] G. Elert, *Frequency of the Lowest Electromagnetic Waves*, <http://hypertextbook.com/facts/2001/ElizabethWong.shtml>. Cited 20 Jul 2007 (2007).